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TrueBeam RapidArc implementation of radiosurgery for benign lesions: first year experience

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Purpose/Objective: Notable radiosurgery (SRS) challenges in benign brain lesions are dose calculation accuracy and efficiency of the process (total time). The purpose of this work is to analyse our first year experience with RapidArc (RA) SRS patients treated at the TrueBeam STx (TB) linear accelerator.

Materials and Methods: At our department patients undergoing SRS are treated in one single fraction with the Brainlab localization frame at TrueBeam.

Initially, iPlan TPS was used to calculate dynamic conformal arc (DCA) plans. Once calculated, the plan was exported to Eclipse and prepared to treatment.

To commission Eclipse (v 13) for SRS, main addressed topics were: spot sizes tuned to reproduce small field measurements (output for jaw sizes down to 1 cm x 1 cm and MLC fields down to 0.5 cm x 0.5 cm) as well as dosimetric leaf gap regarding RA calculations. iPlan plans were re-calculated in Eclipse in order to obtain knowledge-based sets of constraints in the optimisation module and to get the best calculation parameters shortening the total planning time, giving the greatest accuracy achievable. The obtained dose distributions were compared against iPlan ones.

The final process has been established as follows

iPlan is used for segmentation, to allocate non-coplanar arcs (to take profit of previous experience and specificity of this TPS), and to generate Target positioners (Tapos). Plan is exported to Eclipse, structures a re-segmented as high resolution and help structures are defined to control fall-off doses. RA optimisation is performed with AAA algorithm (v13) using the intermediate dose calculation and jaw tracking options, 6MV and recently 6MV FFF are employed. After clinical plan approval, a verification plan is calculated on Octavius4D phantom. Verification is acquired with the 1000SRS detector and analysed using 3D local gamma criteria (2%/2mm, 1%/1mm). If the verification criteria are met patient goes to treatment. Tapos are used to firstly position the patient and then a CBCT is acquired to obtain the final position (6D couch movements).

Results for the commissioning comparisons and the first patients treated are presented, Paddick conformity index is reported.

Results: A total of 45 benign lesions (schwanoma: 18; meningioma: 10; AVM: 7; acoustic neurinoma: 3; others: 7) have been treated at the TrueBeam, 10 with RA following the described process.

The number of employed arcs ranged between 5 and 7.

Sets of optimisation parameters have been obtained for each representative pathology allowing getting plan objectives in only one run.

Most relevant planning involved times (minutes) are: preparation, about 15; optimisation/calculation, from 30 to 50 (number of arcs, grid size, etc.); verification calculation, from 15 to 35.

With RA the conformity index increases about 20% compared to DCA.

Verifications mean gamma passing rates have been 99.6 (2%/2mm) and 97.9 (1%/1mm).

Conclusions: A feasible process has been described to treat SRS benign lesions with RapidArc. An adequate level of efficiency and accuracy is achieved.

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Monte Carlo calculation for Intra-Operative Radiotherapy (IOERT) with electron beams

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Purpose/Objective: The Intra-Operative Radiation Therapy (IORT) is a specialized irradiation technique which allows a single high radiation dose (10 – 25 Gy) delivery during the surgical intervention, after the visible tumor resection.

The choice of protecting shield materials is a compromise between the surgeon's requirement to have it as thin as possible, as well as the necessity to totally absorb the primary radiation. The main aim of this work is to perform Monte Carlo simulation for IOERT beams with different shielding plates in place, and compare it with measurement to check dose in front of and behind the shielding plate. There are a few papers related to IORT but none of them focuses on shielding plate design.

Materials and Methods:

I.A. Monte Carlo Simulation

The Mobetron 1000 head was modeled using the EGSnrc/BEAMnrc simulation package. The dose distribution in water for flat applicators was simulated with the DOSXYZnrc code, which scores dose in a water Phantom. This study is done for the most clinically used applicator (5.5 cm) with the maximum energy used of the accelerator (12MeV). Seven Mobetron components are modeled: electron source, first scattering foil, second scattering foil, fixed collimator #1 , ion monitor chamber, fixed collimator #2 and the patient applicator. It is necessary to validate Monte Carlo model against measurements (PDD, Profile).

A method to find the correct electron beam characteristics impinging on the scattering foil is to change iteratively some parameters and compare the simulations with measurements. We had to optimize the energy spectrum and the FWHM of the Gaussian source.

I.B.Types of Shields studied

There are many shield types used in different Mobetron centers. They are all composed of two materials: either PMMA/Cu, or Al/Pb or Al/Steel. All of them have been simulated with Monte Carlo and some of them have been measured with Radiochromic films. The shield was usually placed at the 90% isodose depth in water.

Results: On figure 1, the matching between measured and calculated PDD and profiles is presented. On figure 2 there is an example of dose map distribution with an Al/Pb shield placed at 3.7cm depth. It is clear that there is no transmission and there is a significant backscattering effect close to the shield. Other types of shields gave similar results for transmission but slightly different results for backscattering.

Interestingly, we can use the backscattering effect to enhance the dose homogeneity in the target volume and a theoretical shield design will be presented.

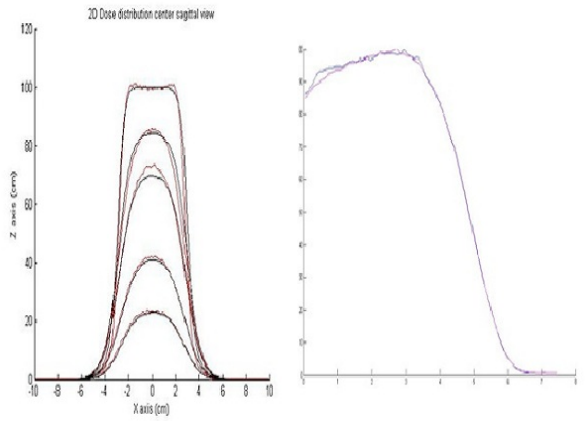

Figure 1: PDD & Profile measured curves and MC simulation

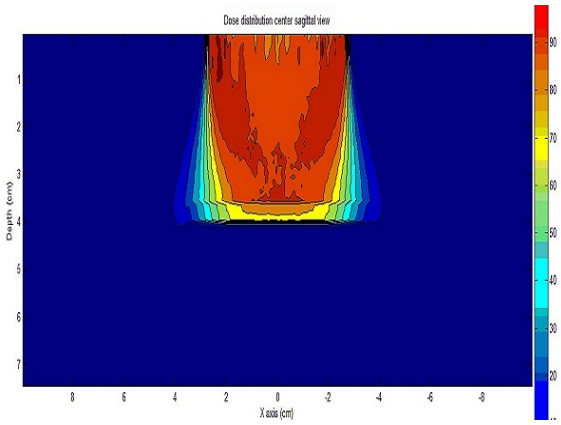

Figure 2: Dose map for a Mobetron 12 MeV Beam, 5.5 cm Applicator and (Al/Pb) shield plate in water phantom

Conclusions:

- All of the studied shielding plates are clinically acceptable. Normally, the surgeon would prefer the thinnest shield (Al/Pb).
- The good alignment of the applicator and the shield is a key issue

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Analysis of the different dose-volume constraints in 3D-CRT breast cancer

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Purpose/Objective: Recent studies have warned about late toxicity, primarily cardiac toxicity, in patients diagnosed with breast cancer who have received radiation therapy.

Although there are numerous publications and protocols there is no uniform recommendations for 3D radiation therapy for breast cancer about which are the best dose/volume constraints to evaluate this treatment.

The purpose of this study is to quantify and compare different dose/volume constraints for the organs at risk (OARs) in breast cancer treatment based in the DVH of each study, in order to establish the most useful parameters to evaluate this type of treatment in our institution.

Materials and Methods: 544 women were evaluated. Studies were grouped regarding the type of treatment (breast/chest wall, breast + boost, breast + regional nodal irradiation (RNI), breast+boost+RNI) and the fractionation scheme (2Gy or 2.66Gy per fraction).

Different dose/volume constraints for the heart and lung have been evaluated for each patient (Table 1).

Also, for each patient the clinical pathology before and after the treatment has been evaluated.

	Ordinary fractionation (2.00Gy/fx)	Hypofractionated (2.66Gy/fx)
Heart	V_{30Gy}<30cc, V_{20Gy}<10%, V_{25Gy}<10%, V_{40Gy}<5%, V_{45Gy}<50%, V_{60Gy}<30%	V_{24Gy}<30cc, V_{16Gy}<10%, V_{20Gy}<10%, V_{32Gy}<5%, V_{36Gy}<50%, V_{Gy}<30%
Ipsilateral lung	V_{30Gy}<200cc, V_{20Gy}<25%, V_{45Gy}<33%, D_{mean}<17Gy	V_{24Gy}<200cc, V_{16Gy}<25%, V_{36Gy}<33%, D_{mean}<17Gy
Both lungs	V_{20Gy}<25%	V_{16Gy}<25%

Results: From 544 patients only 2 developed symptomatic pulmonary complications and 4 patients developed cardiac complications probably related with the radiotherapy treatment.

Regarding the dose/volume constraints:

•For both lungs, V20Gy(16Gy*) <25% is achieved in about 97% of the patients.

•For the ipsilateral lung, Dmean<17 Gy is achieved in more than 95% of the patients, except in treatments which includes the RNI, where only 64% meet the criteria. Furthermore, the criteria V30Gy<200cc is only achieved by 33% of the patients, in the best situation (breast/chest wall hypofractionated) meanwhile for treatments which includes RNI only 9% meet the objective. For V20Gy<25% the results are in same direction as V30Gy<200cc.

•For the heart, V30Gy(24Gy*)<30 cc is achieved by 29% of the patients in the best situation. V20Gy<10%, V40Gy<5% and V25Gy<10% is achieved by 45%, 41.4% and 52% in the best situations, meanwhile V45Gy<50% and V60Gy<30% is achieved by 100%.

(*) value for hypofractionated treatments

Conclusions: The type of treatment have a big influence in the percentage of cases that meet the dose/volume constraints. Treatments which include the RNI have a low percentage of achievements.

According to our data, we can conclude that the V30(24)Gy<30cc for the heart and the V30(24)Gy<200cc for the ipsilateral lung are quite ambitious constraints and presents a strong dependency of the appearance of the RNI.

Also, parameters as the V45Gy<33% , for the ipsilateral lung and V45Gy<50% for the heart, are very relaxed and the achievement of these constraints doesn't mean that the plan would be an optimal plan.